CLAIMS

1. An apparatus for gas cluster ion beam (GCIB) mass or cluster size diagnostics for improving GCIB workpiece processing, comprising:

a vacuum vessel;

a gas cluster ion beam source within the vacuum vessel for producing a gas cluster ion beam;

an accelerator for accelerating the gas cluster ion beam along a trajectory;

a beam gate for controllably interrupting and restoring the gas cluster ion beam;

beam current measurement means disposed along the trajectory at a predetermined distance, L, from said beam gate;

workpiece holding means disposed along the trajectory for holding a workpiece for gas cluster ion beam processing;

control means for providing beam gating signals to said beam gate that controllably interrupt and restore the gas cluster ion beam;

time-of-flight measurement means for measuring the times-of-flight of components of the gas cluster ion beam over said distance, L; and

a time-of-flight analyzer to analyze said times of flight of components of the gas cluster ion beam in order to provide output information relative to GCIB mass or cluster size;

wherein said output information is used in the gas cluster ion beam processing of the workpiece.

2. The apparatus of claim 1, further comprising display means for displaying the times-of-flight of components of the gas cluster ion beam.

3. The apparatus of claim 1, wherein the time-of-flight analyzer calculates the size or mass distribution of

components of the gas cluster ion beam, and the apparatus further comprises display means for displaying the size or mass distribution of the components of the gas cluster ion beam.

4. The apparatus of claim 3 wherein the time-of-flight analyzer calculates the size or mass distribution by analyzing the beam current fall-off characteristics when the gas cluster ion beam is interrupted.

5. The apparatus of claim 3 wherein the time-of-flight analyzer calculates the size or mass distribution by analyzing the beam current rise characteristics when the gas cluster ion beam is restored.

6. The apparatus of claim 1, wherein the time-of-flight analyzer calculates the size-to-charge-ratio distribution of components of the gas cluster ion beam, and the apparatus further comprises display means for displaying the mass-to-charge-ratio of the components of the gas cluster ion beam.

7. The apparatus of claim 6 wherein the time-of-flight analyzer calculates the size-to-charge-ratio distribution by analyzing the beam current fall-off characteristics when the gas cluster ion beam is interrupted.

8. The apparatus of claim 6 wherein the time-of-flight analyzer calculates the size-to-charge-ratio distribution by analyzing the beam current rise characteristics when the gas cluster ion beam is restored.

9. The apparatus of claim 1, wherein the beam current measuring means comprises a faraday cup for collecting beam current signals.

10. The apparatus of claim 1, wherein the accelerator accelerates the gas cluster ion beam to a known energy in the range of from about 1 keV to about 50 keV.

11. The apparatus of claim 1, wherein the beam gate switches the beam on or off during a time that is shorter than the time-of-flight of the gas ion beam clusters of mean mass as they travel said distance, L.

12. An apparatus for gas cluster ion beam (GCIB) mass or cluster size diagnostics for improving GCIB workpiece processing, comprising:

a vacuum vessel;

a gas cluster ion beam source within the vacuum vessel for producing a gas cluster ion beam;

an accelerator for accelerating said gas cluster ion beam along a first trajectory;

a beam deflector for controllably interrupting and restoring the gas cluster ion beam flow along the first trajectory by deflecting the gas cluster ion beam along a second trajectory;

beam current measurement means disposed along the first trajectory at a predetermined distance, L, from said beam deflector;

workpiece holding means disposed along the first trajectory for holding a workpiece for gas cluster ion beam processing;

control means for providing beam deflecting signals to said beam deflector that controllably interrupt and restore the gas cluster ion beam;

time-of-flight measurement means for measuring the times-of-flight of components of the gas cluster ion beam along said distance, L; and

a time-of-flight analyzer to analyze said times of flight of components of the gas cluster ion beam in order to provide output information relative to GCIB mass or cluster size;

wherein said output information is used in the gas cluster ion beam processing of the workpiece.

13. The apparatus of claim 12, wherein the beam deflector switches the gas cluster ion beam from the first trajectory to the second trajectory during a time that is shorter than the time-of-flight of clusters of mean mass as they travel said distance, L.

14. The apparatus of claim 12, further comprising display means for displaying the times-of-flight of components of the gas cluster ion beam.

15. The apparatus of claim 12, wherein the time-of-flight analyzer calculates the size or mass distribution of components of the gas cluster ion beam, and the apparatus further comprises display means for displaying the size or mass distribution of the components of the gas cluster ion beam.

16. The apparatus of claim 15 wherein the time-of-flight analyzer calculates the size or mass distribution by analyzing the beam current fall-off characteristics when the gas cluster ion beam is interrupted.

17. The apparatus of claim 15 wherein the time-of-flight analyzer calculates the size or mass distribution by analyzing the beam current rise characteristics when the gas cluster ion beam is restored.

18. The apparatus of claim 12, wherein the time-of-flight analyzer calculates the size-to-charge-ratio distribution of components of the gas cluster ion beam, and the apparatus further comprises display means for displaying the mass-to-charge-ratio of the components of the gas cluster ion beam.

19. The apparatus of claim 18 wherein the time-of-flight analyzer calculates the size-to-charge-ratio distribution by

analyzing the beam current fall-off characteristics when the gas cluster ion beam is interrupted.

20. The apparatus of claim 18 wherein the time-of-flight analyzer calculates the size-to-charge-ratio distribution by analyzing the beam current rise characteristics when the gas cluster ion beam is restored.

21. The apparatus of claim 12, wherein the beam current measuring means comprises a faraday cup for collecting beam current signals.

22. The apparatus of claim 12, wherein the accelerator accelerates the gas cluster ion beam to a known energy in the range of from about 1 keV to about 50 keV.

23. An apparatus for gas cluster ion beam (GCIB) mass or cluster size diagnostics for improving GCIB workpiece processing, comprising:

a vacuum vessel;

a gas cluster ion beam source within the vacuum vessel for producing a gas cluster ion beam;

an accelerator for accelerating the gas cluster ion beam along a trajectory;

a beam gate for controllably interrupting and restoring the gas cluster ion beam;

beam current measurement means disposed along the trajectory at a predetermined distance, L, from said beam gate;

control means for providing beam gating signals to said beam gate that controllably interrupt and restore the gas cluster ion beam;

time-of-flight measurement means for measuring the times-of-flight of components of the gas cluster ion beam over said distance, L; and

a time-of-flight analyzer to analyze said times of flight of components of the gas cluster ion beam in order

to provide output information relative to GCIB mass or cluster size.

24. An apparatus for gas cluster ion beam (GCIB) mass or cluster size diagnostics for improving GCIB workpiece processing, comprising:

a vacuum vessel;

a gas cluster ion beam source within the vacuum vessel for producing a gas cluster ion beam;

an accelerator for accelerating said gas cluster ion beam along a first trajectory;

a beam deflector for controllably interrupting and restoring the gas cluster ion beam flow along the first trajectory by deflecting the gas cluster ion beam along a second trajectory;

beam current measurement means disposed along the first trajectory at a predetermined distance, L, from said beam deflector;

control means for providing beam deflecting signals to said beam deflector that controllably interrupt and restore the gas cluster ion beam;

time-of-flight measurement means for measuring the times-of-flight of components of the gas cluster ion beam along said distance, L; and

a time-of-flight analyzer to analyze said times of flight of components of the gas cluster ion beam in order to provide output information relative to GCIB mass or cluster size.

25. A method of measuring a characteristic of an ion beam comprising the steps of:

projecting the ion beam along a path having a predetermined length;

collecting the ion beam current;

abruptly switching the ion beam at a time t_0 to produce a current transient;

measuring the current transient; and

processing the current transient measurement to calculate a characteristic of the ion beam.

26. The method of claim 25 further comprising the step of displaying the calculated characteristic of the ion beam.

27. The method of claim 25 wherein the ion beam is a cluster ion beam.

28. The method of claim 25 wherein the abruptness of the switching is less than the mean ion flight time across the predetermined length.

29. The method of claim 25 wherein the switching step comprises the step of switching the beam off and wherein the current transient is a current decrease.

30. The method of claim 25 wherein the switching step comprises the step of switching the beam on and wherein the current transient is a current increase.

31. The method of claim 25 wherein the processing step further comprises the step of taking a derivative of the current transient after time t_0.

32. The method of claim 25 wherein the processing step further comprises the steps of:

taking a derivative of the current transient after time t_0; and

dividing the derivative of the current transient by time t which is defined as the time required for the ion beam to travel along the predetermined length.

33. The method of claim 27 wherein the characteristic of the cluster ion beam is a cluster size.

34. The method of claim 27 wherein the characteristic of the cluster ion beam is a cluster size distribution function.

35. The method of claim 27 wherein the characteristic of the cluster ion beam is a cluster size-to-charge-ratio distribution function.